DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

FOUR QUADRANT OPEN WATER CHARACTERISTICS OF CONTROLLABLE PITCH PROPELLER 4739 DESIGNED FOR LSD-41 (MODEL 5367)

BY

GARY A. HAMPTON

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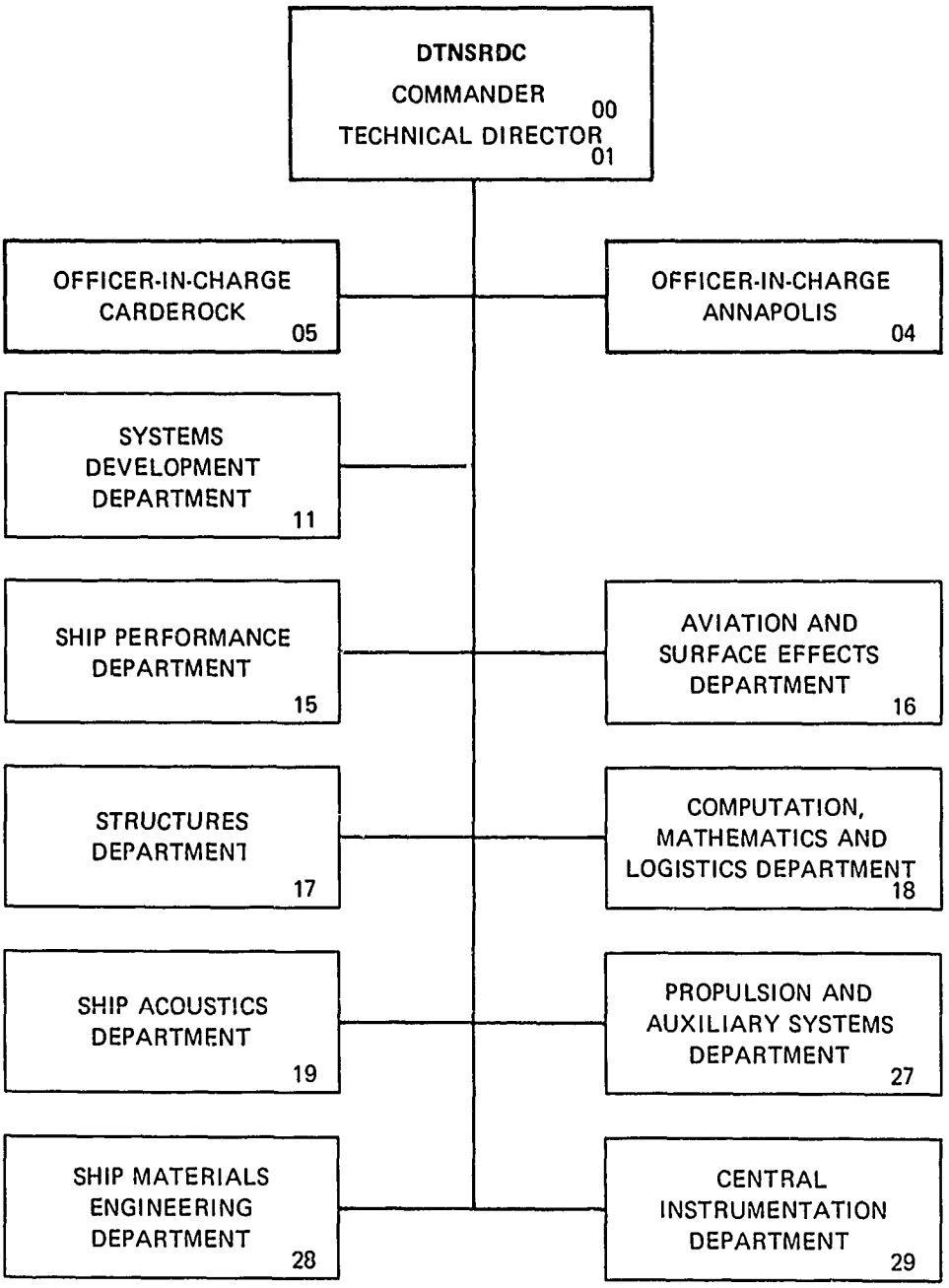

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report presents the results of an experimental program conducted to evaluate the open water thrust and torque on a controllable reversible pitch design propeller for the Dock Landing Ship (LSD-41).

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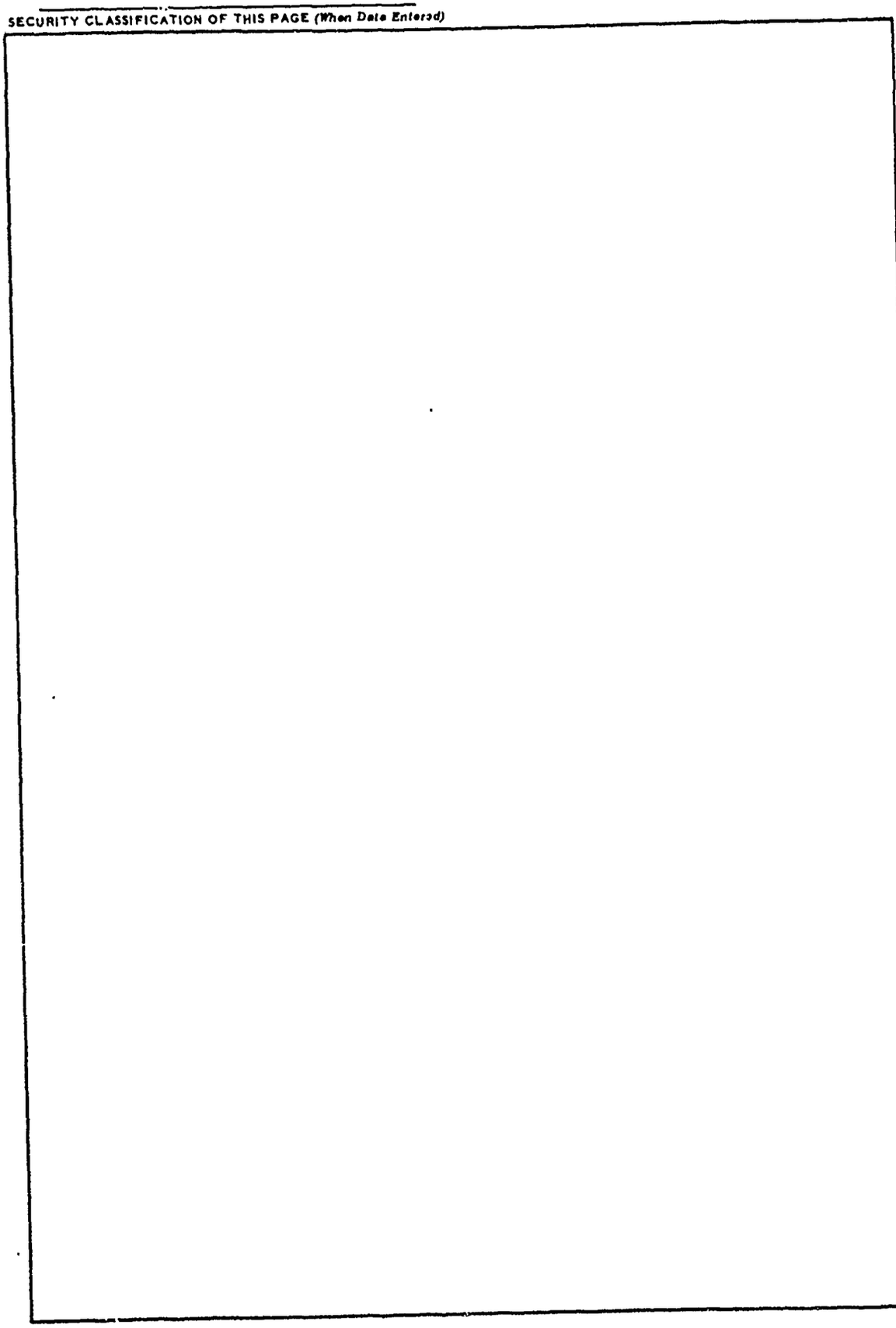

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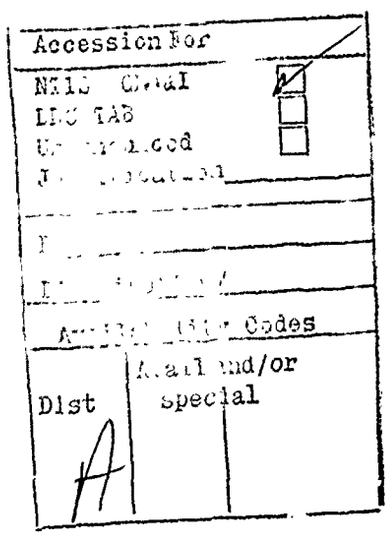

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NOTATION

C_Q	Modified Torque Coefficient = $Q/\rho D^3 \ (V_A^2 + n^2 D^2)$
C_T	Modified Thrust Coefficient = $T/\rho D^2 \ (V_A^2 + n^2 D^2)$
D	Propeller Diameter
J	Advance Coefficient = V_A/nD
K_Q	Torque Coefficient = $Q/\rho \ n^2 \ D^5$
K_T	Thrust Coefficient = $T/\rho \ n^2 \ D^4$
n	Rate of Revolution
P	Propeller Pitch
Q	Propeller Torque
T	Propeller Thrust
V_A	Propeller Speed of Advance
μ	Modified Advance Coefficient = $V_A/\sqrt{V_A^2 + n^2 D^2}$
ρ	Density

METRIC CONVERSIONS

1 foot	= 0.3048 m (meters)
1 inch	= 25.40 m (millimeters)
1 knot	= 0.5144 m/s (meters per second)
1 fps	= 0.3048 m/s (meters per second)
1 lb (force)	= 4.448 N (Newtons)
1 lb (force)	= 0.1130 N·m (Newton-meter)
1 ton (2240 lbs)	= 1.016 t (metric ton)
1 horsepower	= 0.746 KW (kilowatts)
1 inch Mercury	= 3.38 kPa (kilopascals)

ABSTRACT

An experimental program was conducted at the David W. Taylor Naval Ship R&D Center (DTNSRDC) to evaluate the thrust and torque on the design propeller of the Dock Landing Ship (LSD-41) over a wide range of operating conditions. The analysis revealed no unusual results with regard to performance

ADMINISTRATIVE INFORMATION

The Naval Sea Systems Command (NAVSEA) Code 521 initiated a model experimental program at DTNSRDC to design and evaluate the open water performance of the propeller for the LSD-41. Work was authorized by NAVSEA Work Request 92131 dated 16 January 1979 and the work was performed under DTNSRDC Work Unit Number 1-1524-692.

INTRODUCTION

Propeller 4739 is a controllable reversible pitch propeller for the new Dock Landing Ship (LSD-41). The propeller was designed, manufactured and evaluated for open water performance at the David W. Taylor Naval Ship Research & Development Center (DTNSRDC). The blades were adjustable so that various pitch angles could be evaluated. The blade pitches were set by inserting specially designed pitch blocks attached to the root of the blade which gave the proper blade angle when inserted into the hub. The experiments were performed in the DTNSRDC Carriage I Towing Basin Facility Various operating conditions were simulated in the Basin and investigated for thrust and torque over a wide range of operating conditions. A schematic drawing of Propeller 4739 is shown in Figure 1 and studio

photographs are presented in Figure 2. Listed below are some of the full scale and model dimensions of the propeller.

	Model Scale	Full Scale
Diameter	14.616 in (37.11 cm)	13.50 ft (4.11 m)
Chord at .7R	3.072 in (7.80 cm)	5.44 ft (1.66 m)
Pitch at .7R	11.520 in (29.26 cm)	20.40 ft (6.22 m)
Number of Blades	5	5

DYNAMOMETRY

Propeller thrust and torque were measured by using a variable reluctance 100 in-lb transmission dynamometer. Power to rotate the propeller was supplied by a single constant torque motor selected for its ability to control the shaft rotation rate through all experimental conditions. Propeller rpm and propeller boat velocity were determined respectively by a Hewlett Packard rotopulser and a revolution-speed-time recorder. Propeller depth of submergence during the entire experiment was 13.5 inches (34.29 cm) at the shaft centerline.

The transmission dynamometer was calibrated over a range of -100 to +100 lbs (-444.8 to 444.8 N) for thrust and -120 to +120 in-lbs (-13,56 to 13.56 N.m) for torque. The response of the dynamometer for both thrust and torque remained linear with applied load. A check calibration was performed after the completion of the experiments to confirm the repeatability of the dynamometer data. The before and after dynamometer calibrations were in agreement.

EXPERIMENTAL PROCEDURE

Experiments were conducted in uniform flow over a range of positive and negative advance coefficients representing 120% to -70% of design pitch. These experimental conditions represented a quasi-steady simulation of the various modes of propeller operation including steady ahead, steady backing, crashback and crashahead.

Table 1 lists the experimental conditions. Each condition was established by setting the propeller rpm and propeller boat velocity to achieve a given advance coefficient. To obtain uniform flow into the propeller, it was necessary to drive the propeller from downstream for all conditions. All experimental conditions were run in one direction in the basin. Conditions with astern velocity on the ship (such as steady backing and crashahead) were simulated in the experiments by rotating the blades 180 degrees about the axis and reversing the direction of shaft rotation.

DATA ACQUISITION AND ANALYSIS

All data were digitized and analyzed by using an analog-to-digital converter and an Interdata minicomputer (Model 70). The records of thrust, torque, rotational speed, and speed of advance were digitized and averaged over a 5-sec time interval. Computer programs were developed for the Interdata minicomputer to enable an on-line data analysis. This included subtraction of "no loads", and nondimensionalization by the appropriate factors. The data were printed out as a function of advance coefficient for immediate plotting and checking.

RESULTS

There are several ways to present open water data over the complete range of advance coefficients from locked shaft ahead to locked shaft astern. All data in this report is presented in two forms, the $K_T - K_Q - J$ system and the $C_T - C_Q - \mu$ system. Furthermore, whenever any value of K_T, $10K_Q$, or J exceeds 1.0, conversion to $1/J$, $1/K_T$, or $1/10K_Q$ is made for plotting purposes. Definition of the various coefficients are given in the notation.

Tables 2 through 17 and Figures 3 through 10 are the results of the open water experiments. The figures show both the experimental data points and the faired line representing these data. The tabulated data are faired data only. The faired data were obtained by calculating K_T, K_Q, and J as well as C_T, C_Q, and μ from the measured quantities (thrust, torque, speed and rpm). K_T and K_Q were each faired independently against J using a standard least squares computer routine. The polynomial coefficients were then used to provide the tabulated data at even values of J. Similarly, the data in the C_T and C_Q form were faired against μ and values of C_T and C_Q calculated at values of μ which corresponded to the tabulated values of J. Since the two forms of data were faired independently, some insignificant differences occur if one tries to convert from one set of coefficients to the other.

CONCLUSIONS

In conclusion, an inspection of the data reveals that there are no unusual results with regard to thrust and torque performance over the range of simulated operating conditions.

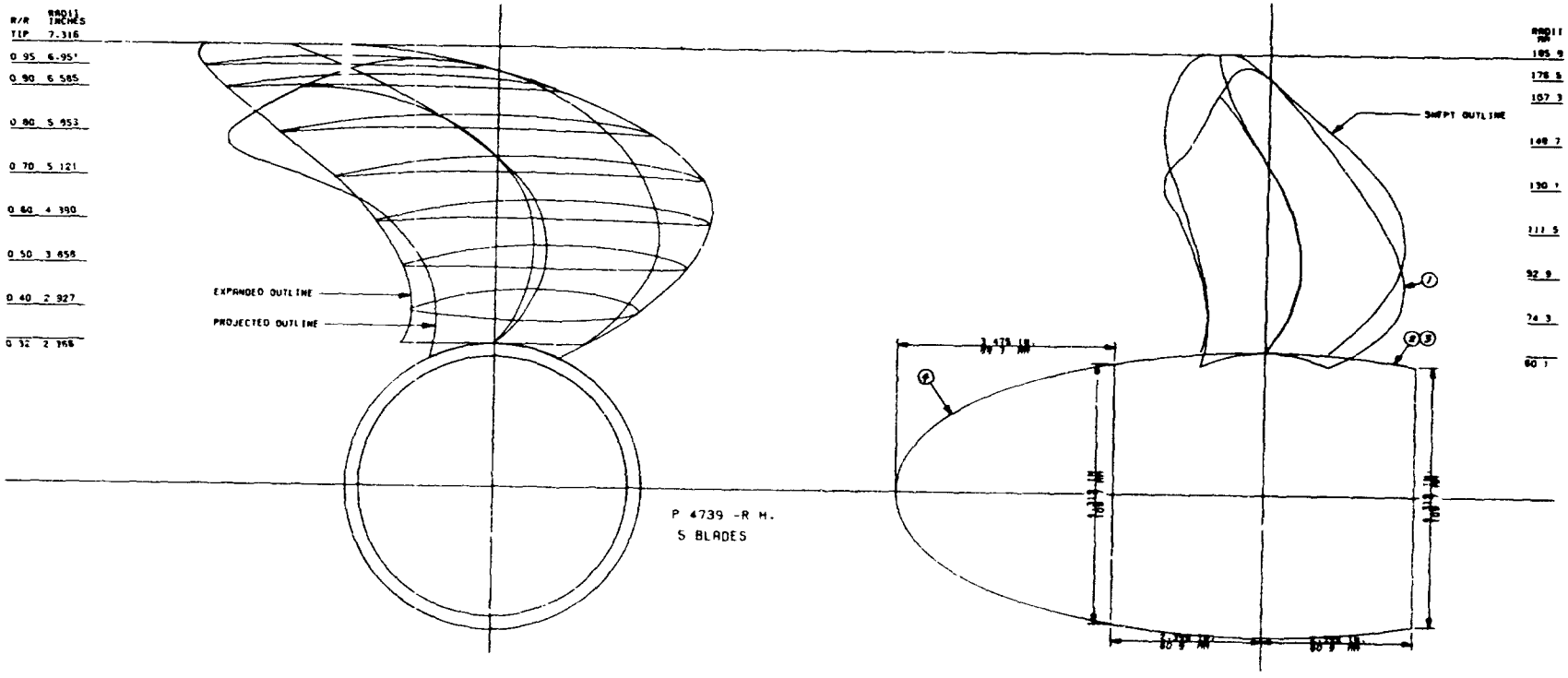

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Figure 1 - Drawing of Propeller 4739

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PSD-1851-3-79

Figure 2 - Studio Photographs of Propeller 4739

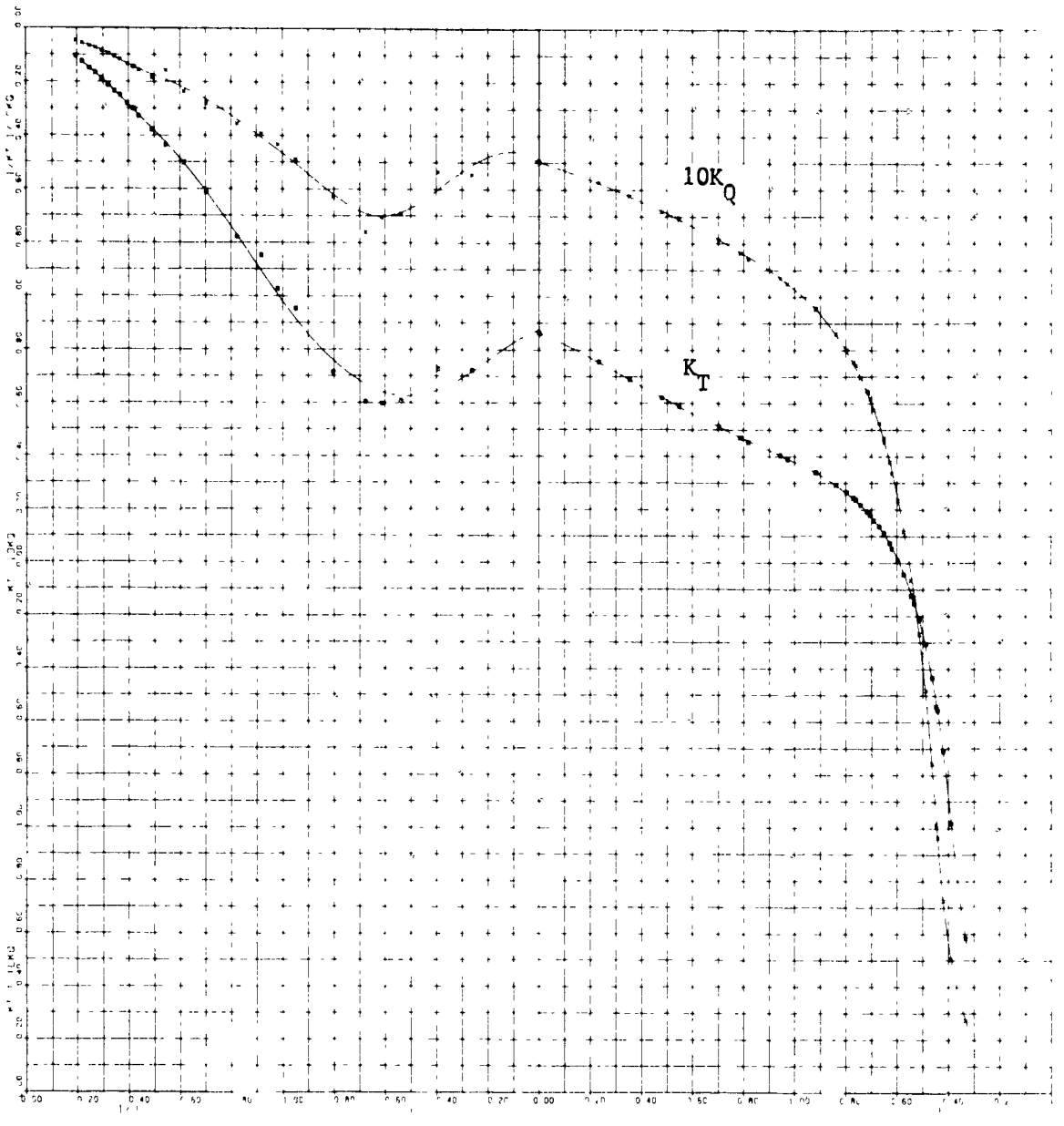

Figure 3 - Open Water Thrust and Torque P/D = 1.813

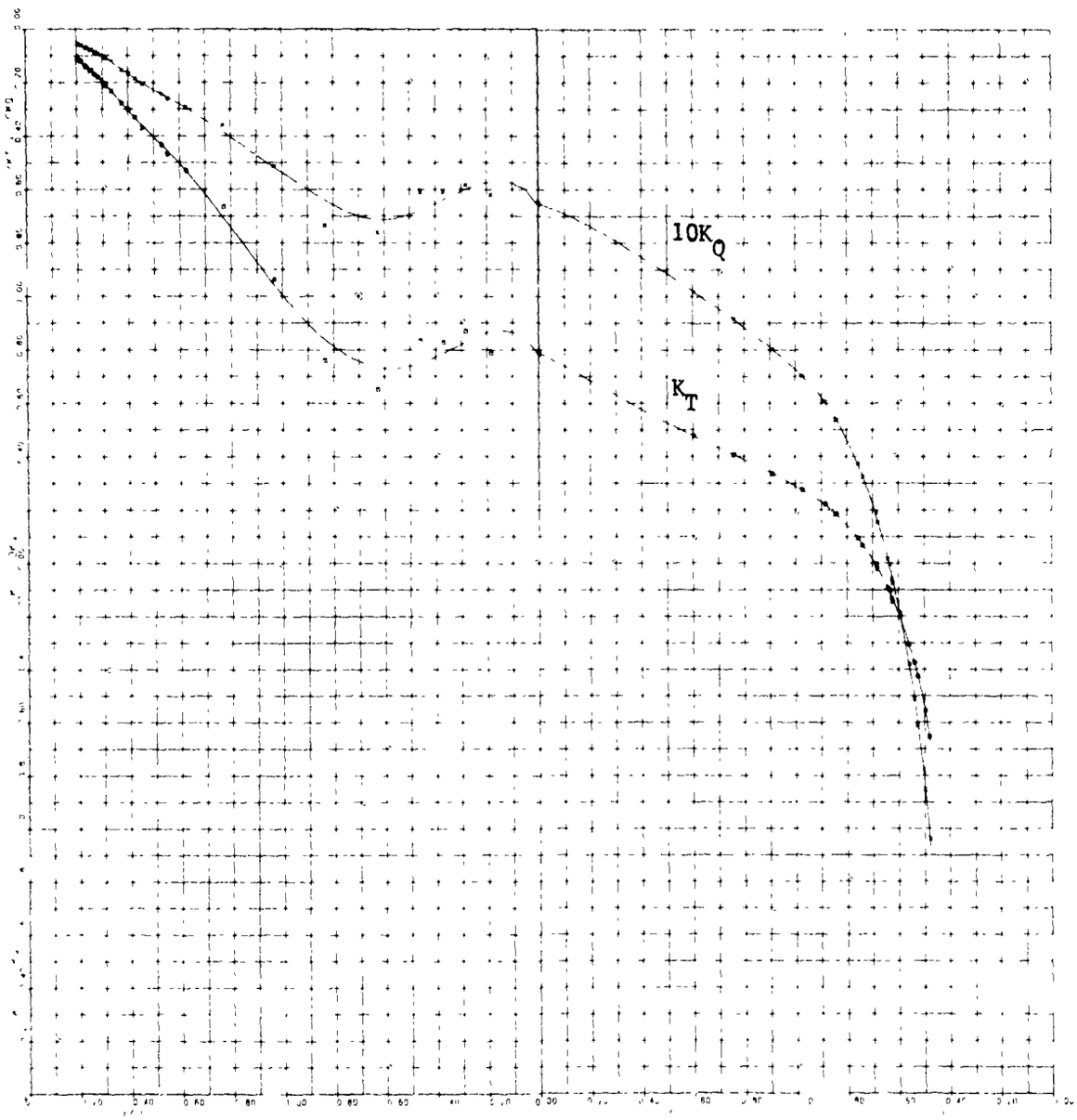

Figure 4 - Open Water Thrust and Torque P/D = 1.511

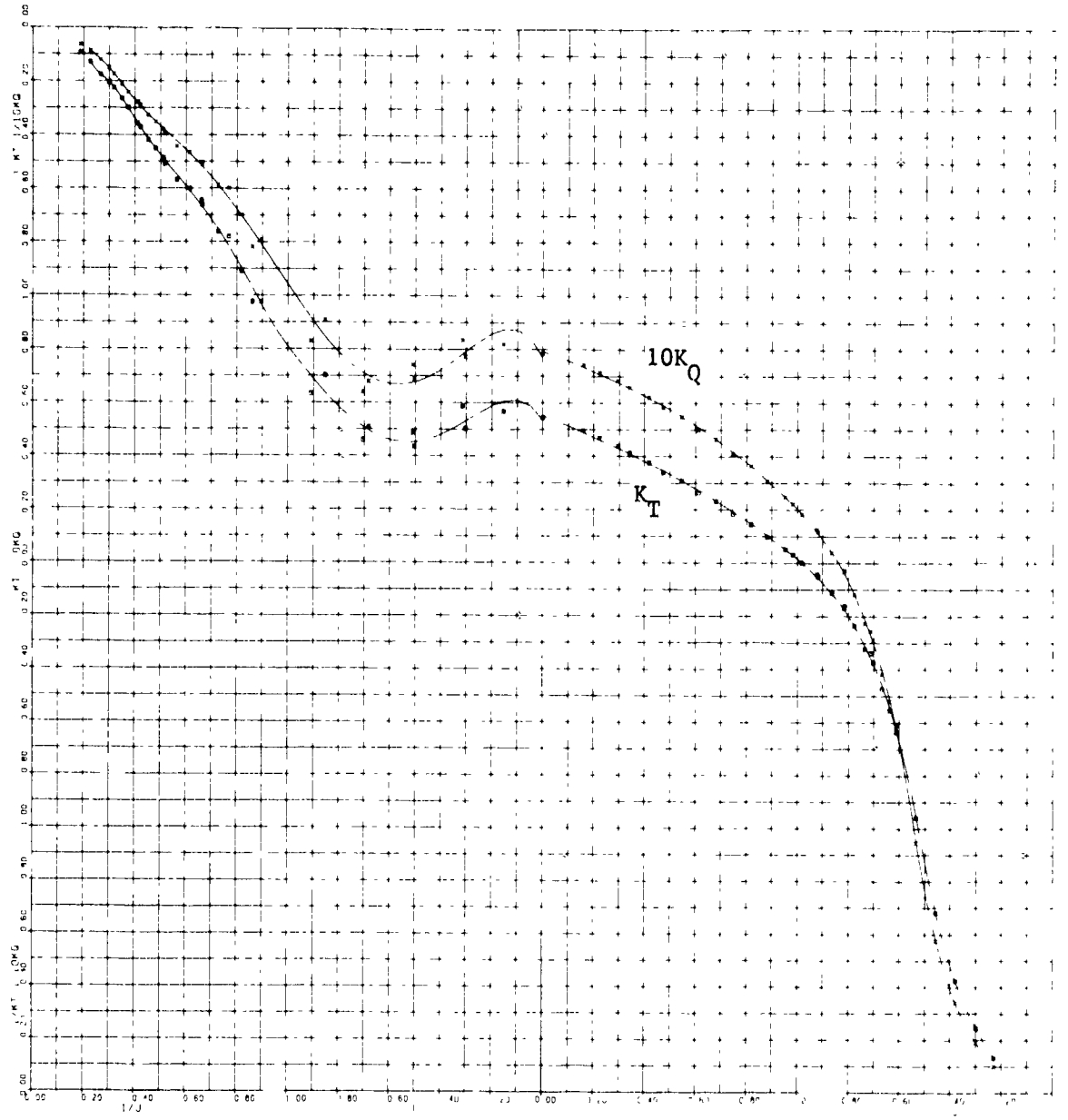

Figure 5 - Open Water Thrust and Torque P/D = 1.058

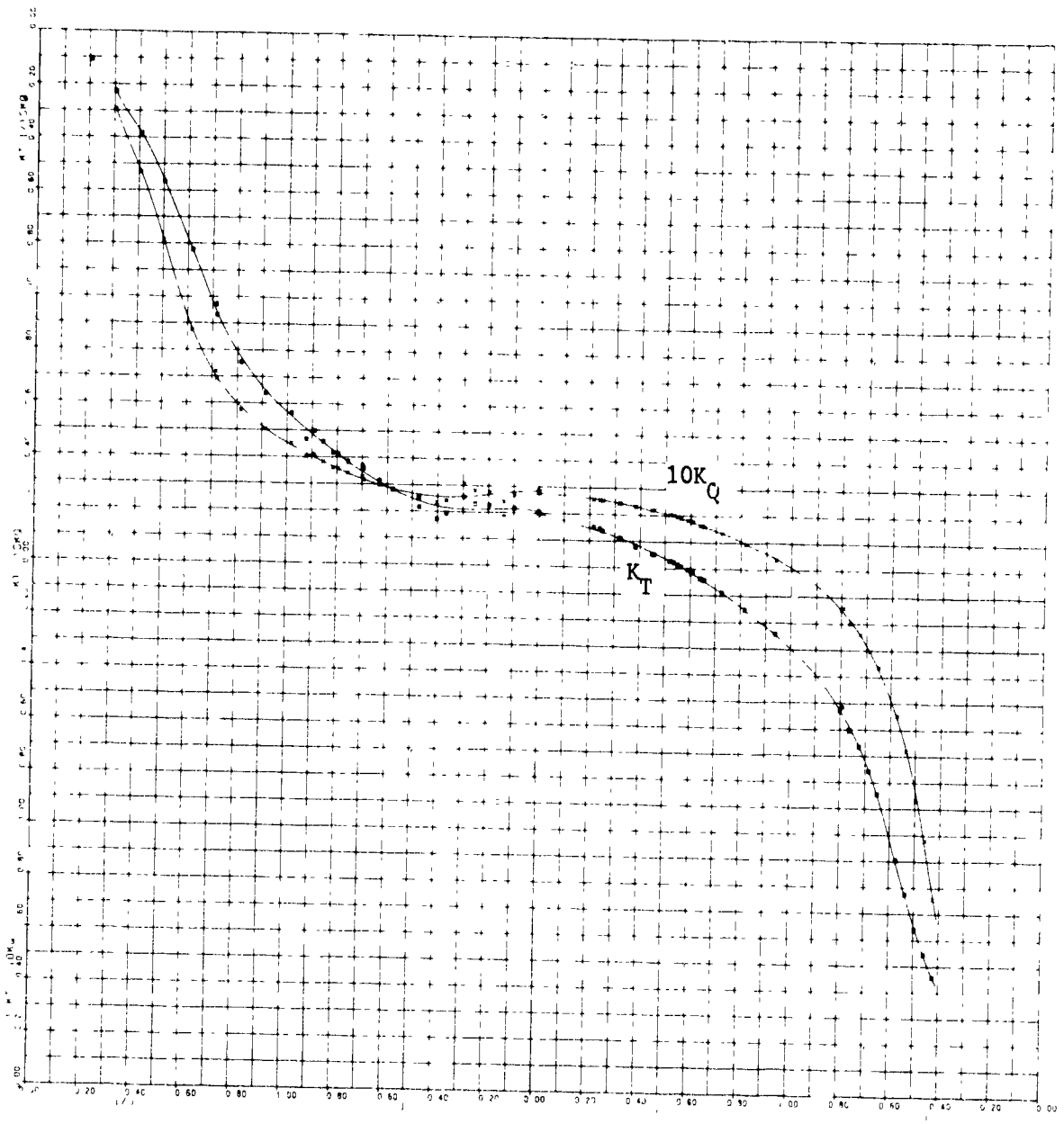

Figure 6 - Open Water Thrust and Torque P/D = 0.604

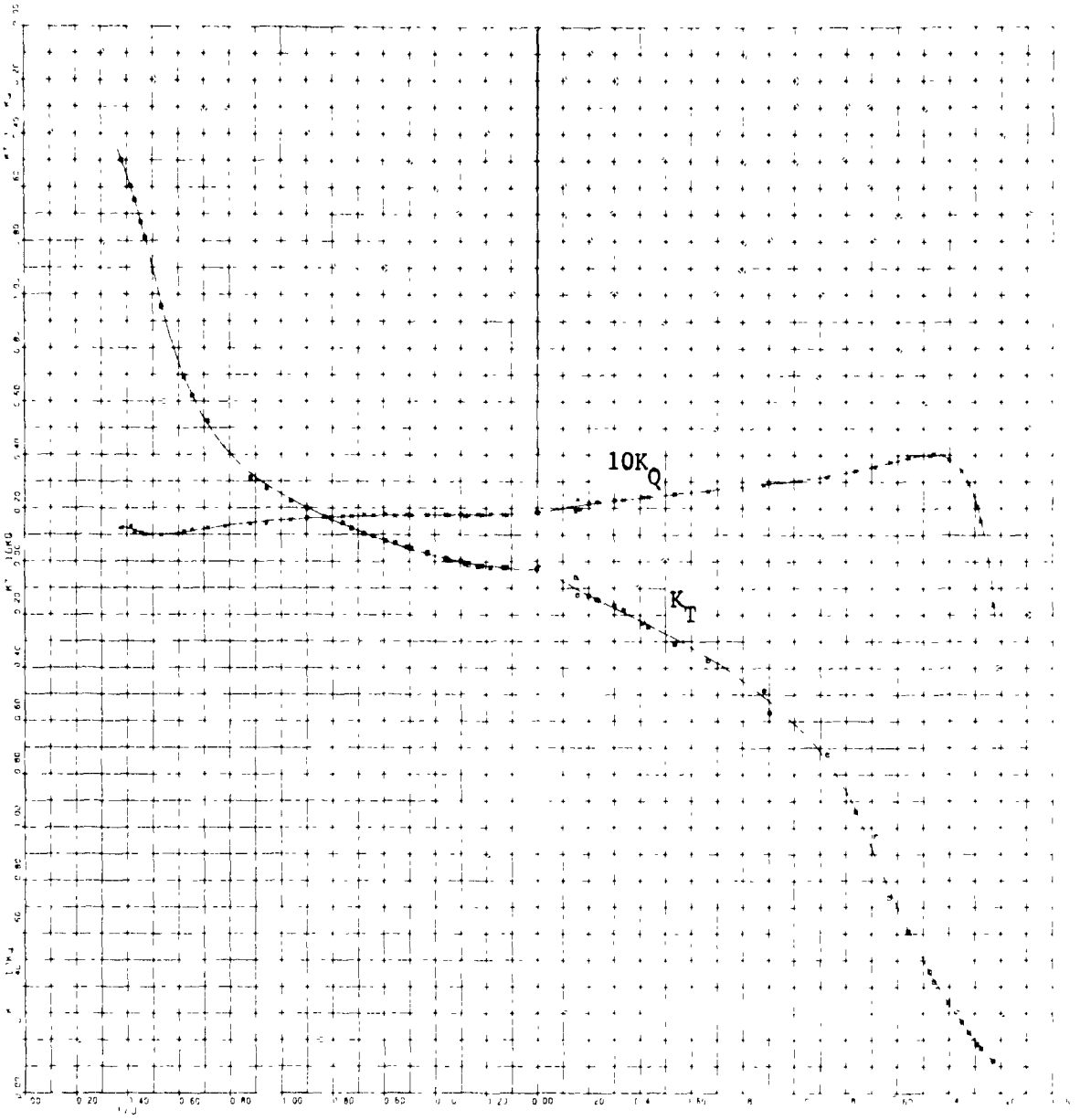

Figure 7 - Open Water Thrust and Torque P/D = 0.000

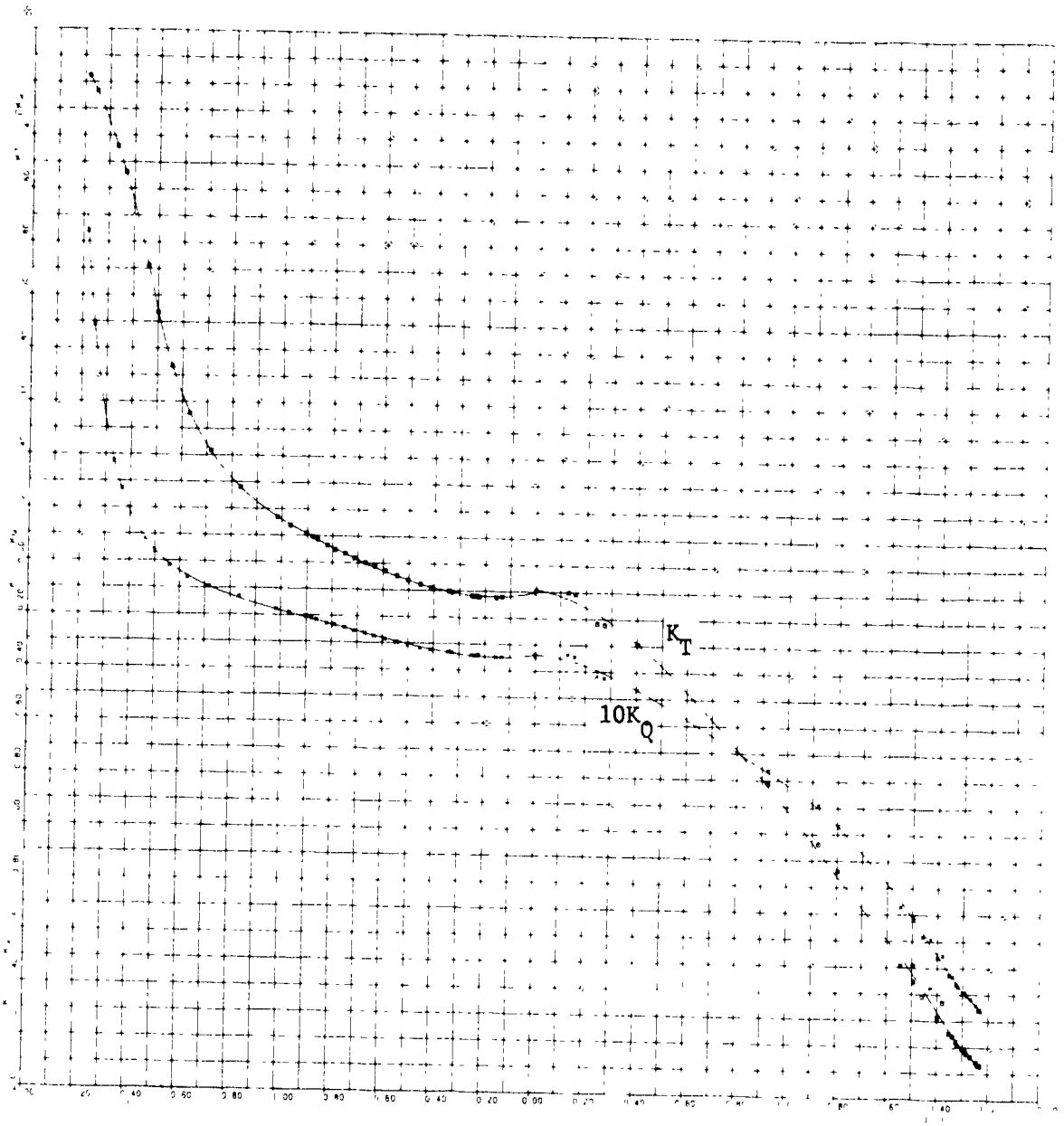

Figure 8 - Open Water Thrust and Torque P/D = -0.302

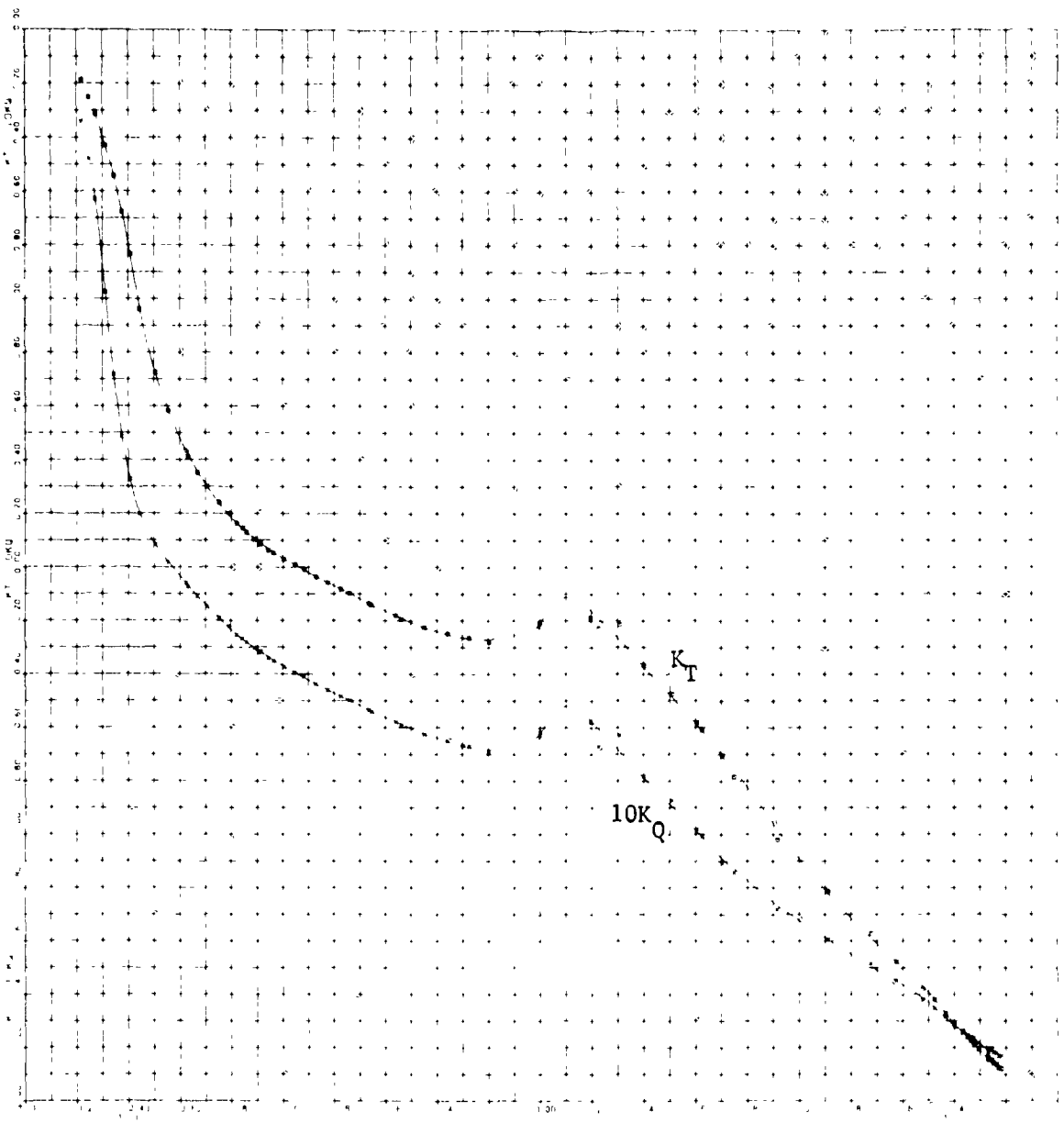

Figure 9 - Open Water Thrust and Torque P/D = -0.604

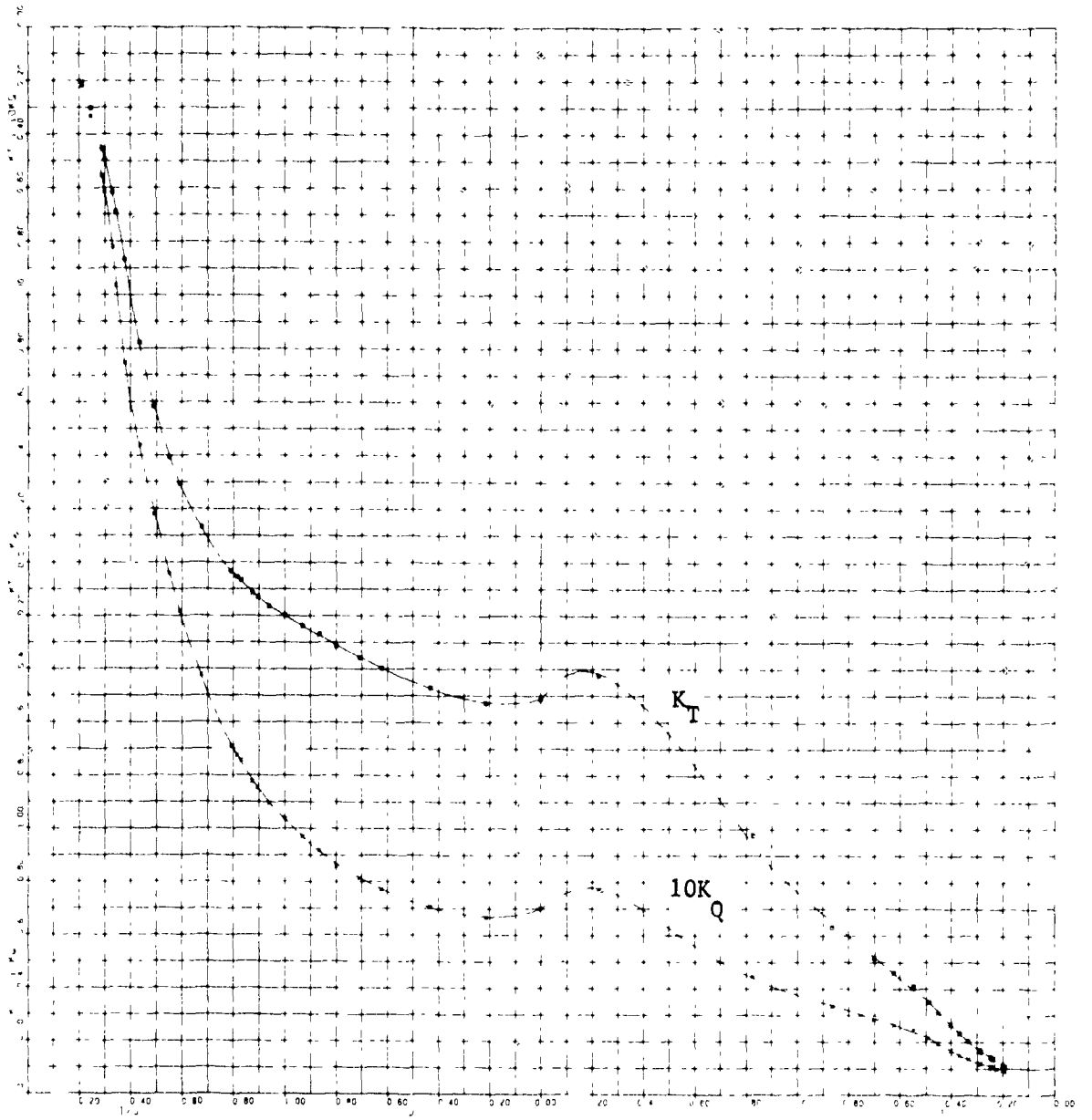

Figure 10 - Open Water Thrust and Torque P/D = -1.058

TABLE 1

EXPERIMENTAL CONDITIONS

P/D	Condition	Figure Number	Table Number
1.813	Ahead	3	2
	Crashahead	3	3
1.511	Ahead	4	4
	Crashahead	4	5
1.058	Ahead	5	6
	Crashahead	5	7
0.604	Ahead	6	8
	Crashahead	6	9
0.000	Backing	7	10
	Crashback	7	11
-0.302	Backing	8	12
	Crashback	8	13
-0.604	Backing	9	14
	Crashback	9	15
-1.058	Backing	10	16
	Crashback	10	17

TABLE 2

Faired Open Water Characteristics
P/D = 1.813 Ahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.862	2.011	0.000	.861	2.008
.050	.842	1.952	.050	.842	1.951
.100	.820	1.893	.100	.813	1.876
.150	.796	1.833	.148	.778	1.792
.200	.770	1.774	.196	.739	1.703
.250	.744	1.717	.243	.699	1.613
.300	.717	1.660	.287	.657	1.522
.350	.690	1.606	.330	.615	1.431
.400	.664	1.553	.371	.573	1.341
.450	.637	1.502	.410	.531	1.252
.500	.611	1.453	.447	.490	1.165
.550	.586	1.406	.482	.451	1.081
.600	.561	1.361	.514	.413	1.001
.650	.537	1.317	.545	.377	.925
.700	.513	1.274	.573	.343	.854
.750	.490	1.233	.600	.312	.787
.800	.467	1.192	.625	.283	.724
.850	.445	1.152	.648	.257	.666
.900	.423	1.111	.669	.232	.612
.950	.401	1.071	.689	.210	.561
1.000	.379	1.030	.707	.189	.514
1.050	.357	.987	.724	.170	.469
1.100	.335	.944	.740	.152	.427
1.150	.312	.898	.755	.135	.388
1.200	.289	.851	.768	.119	.350
1.250	.265	.801	.781	.105	.314
1.300	.241	.749	.793	.091	.280
1.350	.215	.693	.804	.077	.248
1.400	.188	.635	.814	.065	.216
1.450	.159	.572	.823	.052	.186
1.500	.130	.506	.832	.041	.157
1.550	.098	.436	.840	.029	.130
1.600	.065	.362	.848	.019	.103
1.650	.031	.283	.855	.008	.077
1.700	-.006	.200	.862	-.002	.052
1.750	-.045	.113	.868	-.011	.028
1.800	-.086	.021	.874	-.021	.005
1.850	-.128	-.076	.880	-.030	-.017
1.900	-.173	-.177	.885	-.038	-.039
1.950	-.220	-.284	.890	-.047	-.059
2.000	-.270	-.394	.894	-.055	-.080
2.050	-.321	-.510	.899	-.063	-.099
2.100	-.375	-.630	.903	-.070	-.118

TABLE 3

Faired Open Water Characteristics
P/D = 1.813 Crashahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.873	2.004	0.000	.873	2.002
-.050	.855	2.143	-.050	.853	2.143
-.100	.827	2.186	-.100	.819	2.165
-.150	.794	2.161	-.148	.777	2.109
-.200	.759	2.089	-.196	.730	2.004
-.250	.725	1.988	-.243	.682	1.871
-.300	.693	1.875	-.287	.636	1.724
-.350	.667	1.760	-.330	.594	1.574
-.400	.646	1.654	-.371	.557	1.431
-.450	.632	1.562	-.410	.526	1.302
-.500	.626	1.492	-.447	.501	1.191
-.550	.628	1.445	-.482	.482	1.104
-.600	.638	1.424	-.514	.468	1.039
-.650	.656	1.431	-.545	.460	.998
-.700	.682	1.464	-.573	.457	.976
-.750	.715	1.523	-.600	.457	.972
-.800	.755	1.607	-.625	.460	.982
-.850	.803	1.713	-.648	.466	1.000
-.900	.856	1.840	-.669	.473	1.026
-.950	.915	1.984	-.689	.482	1.054
-1.000	.978	2.143	-.707	.490	1.084
-1.050	1.046	2.315	-.724	.499	1.112
-1.100	1.118	2.497	-.740	.507	1.138
-1.150	1.193	2.685	-.755	.514	1.162
-1.200	1.271	2.879	-.768	.521	1.181
-1.250	1.351	3.076	-.781	.527	1.197
-1.300	1.432	3.274	-.793	.532	1.210
-1.350	1.515	3.470	-.804	.536	1.218
-1.400	1.599	3.665	-.814	.539	1.224
-1.450	1.683	3.857	-.823	.541	1.226
-1.500	1.768	4.044	-.832	.542	1.226
-1.550	1.853	4.227	-.840	.543	1.223
-1.600	1.938	4.404	-.848	.543	1.219
-1.650	2.023	4.577	-.855	.542	1.213
-1.700	2.107	4.744	-.862	.540	1.206
-1.750	2.192	4.907	-.868	.538	1.197
-1.800	2.276	5.066	-.874	.536	1.184
-1.850	2.360	5.222	-.880	.533	1.178
-1.900	2.444	5.375	-.885	.530	1.168
-1.950	2.528	5.526	-.890	.527	1.157
-2.000	2.612	5.677	-.894	.523	1.146
-2.050	2.697	5.828	-.899	.519	1.135
-2.100	2.781	5.981	-.903	.516	1.124

TABLE 4

Faired Open Water Characteristics
P/D = 1.511 Ahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.789	1.534	0.000	.789	1.534
.050	.766	1.495	.050	.764	1.491
.100	.741	1.451	.100	.733	1.437
.150	.714	1.404	.148	.698	1.374
.200	.686	1.356	.196	.660	1.305
.250	.658	1.308	.243	.619	1.232
.300	.631	1.262	.287	.579	1.157
.350	.604	1.217	.330	.538	1.083
.400	.577	1.174	.371	.498	1.011
.450	.552	1.133	.410	.459	.942
.500	.527	1.094	.447	.422	.875
.550	.503	1.058	.482	.386	.812
.600	.479	1.022	.514	.353	.752
.650	.456	.988	.545	.321	.695
.700	.434	.954	.573	.291	.641
.750	.411	.920	.600	.263	.589
.800	.388	.885	.625	.236	.540
.850	.365	.849	.648	.211	.493
.900	.341	.811	.669	.188	.449
.950	.316	.771	.689	.166	.405
1.000	.290	.728	.707	.145	.363
1.050	.263	.682	.724	.125	.323
1.100	.235	.633	.740	.106	.285
1.150	.206	.580	.755	.089	.249
1.200	.175	.524	.768	.072	.214
1.250	.142	.464	.781	.056	.181
1.300	.108	.400	.793	.041	.149
1.350	.073	.333	.804	.026	.119
1.400	.036	.263	.814	.013	.090
1.450	-.003	.189	.823	-.000	.062
1.500	-.043	.113	.832	-.013	.036
1.550	-.085	.033	.840	-.025	.011
1.600	-.128	-.048	.848	-.036	-.013
1.650	-.173	-.133	.855	-.047	-.035
1.700	-.219	-.220	.862	-.057	-.057
1.750	-.267	-.310	.868	-.066	-.077
1.800	-.317	-.403	.874	-.076	-.097
1.850	-.369	-.500	.880	-.084	-.115
1.900	-.423	-.602	.885	-.093	-.133
1.950	-.481	-.710	.890	-.101	-.150
2.000	-.541	-.824	.894	-.108	-.166
2.050	-.606	-.948	.899	-.116	-.181
2.100	-.676	-1.084	.903	-.123	-.196

TABLE 5

Faired Open Water Characteristics
P/D = 1.511 Crashahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.781	1.517	0.000	.781	1.516
-.050	.839	1.665	-.050	.836	1.661
-.100	.867	1.740	-.100	.859	1.724
-.150	.874	1.762	-.148	.855	1.722
-.200	.865	1.746	-.196	.831	1.677
-.250	.846	1.705	-.243	.796	1.603
-.300	.823	1.651	-.287	.754	1.515
-.350	.797	1.591	-.330	.710	1.419
-.400	.774	1.532	-.371	.668	1.324
-.450	.754	1.481	-.410	.628	1.234
-.500	.740	1.441	-.447	.593	1.153
-.550	.732	1.414	-.482	.562	1.084
-.600	.732	1.402	-.514	.538	1.028
-.650	.740	1.407	-.545	.519	.985
-.700	.756	1.429	-.573	.506	.955
-.750	.780	1.466	-.600	.498	.936
-.800	.812	1.520	-.625	.494	.926
-.850	.850	1.587	-.648	.493	.924
-.900	.896	1.668	-.669	.495	.926
-.950	.948	1.761	-.689	.499	.931
-1.000	1.004	1.863	-.707	.504	.938
-1.050	1.066	1.974	-.724	.509	.945
-1.100	1.132	2.092	-.740	.514	.952
-1.150	1.201	2.216	-.755	.519	.958
-1.200	1.272	2.344	-.768	.523	.962
-1.250	1.346	2.475	-.781	.526	.965
-1.300	1.421	2.607	-.793	.528	.966
-1.350	1.497	2.740	-.804	.529	.965
-1.400	1.573	2.873	-.814	.530	.963
-1.450	1.650	3.006	-.823	.530	.960
-1.500	1.727	3.137	-.832	.529	.955
-1.550	1.804	3.267	-.840	.527	.950
-1.600	1.880	3.396	-.848	.525	.944
-1.650	1.956	3.523	-.855	.523	.937
-1.700	2.031	3.649	-.862	.520	.931
-1.750	2.106	3.774	-.868	.516	.923
-1.800	2.180	3.899	-.874	.512	.916
-1.850	2.254	4.024	-.880	.509	.909
-1.900	2.328	4.149	-.885	.505	.902
-1.950	2.402	4.276	-.890	.501	.895
-2.000	2.477	4.405	-.894	.496	.888
-2.050	2.551	4.536	-.899	.492	.881
-2.100	2.627	4.671	-.903	.488	.875

TABLE 6

Faired Open Water Characteristics
P/D = 1.058 Ahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.552	.793	0.000	.551	.790
.050	.532	.775	.050	.533	.776
.100	.512	.756	.100	.509	.751
.150	.492	.737	.148	.481	.720
.200	.471	.717	.196	.451	.687
.250	.449	.697	.243	.421	.652
.300	.428	.675	.287	.391	.617
.350	.405	.652	.330	.360	.580
.400	.382	.628	.371	.330	.542
.450	.357	.603	.410	.298	.503
.500	.332	.576	.447	.267	.463
.550	.306	.547	.482	.237	.423
.600	.279	.517	.514	.206	.382
.650	.251	.485	.545	.177	.342
.700	.222	.451	.573	.149	.303
.750	.191	.415	.600	.122	.265
.800	.159	.377	.625	.096	.228
.850	.125	.337	.648	.072	.193
.900	.090	.295	.669	.049	.160
.950	.054	.250	.689	.027	.128
1.000	.016	.203	.707	.007	.099
1.050	-.024	.153	.724	-.013	.070
1.100	-.065	.102	.740	-.030	.044
1.150	-.108	.047	.755	-.047	.019
1.200	-.153	-.010	.768	-.063	-.005
1.250	-.200	-.070	.781	-.078	-.028
1.300	-.249	-.132	.793	-.092	-.049
1.350	-.300	-.198	.804	-.106	-.069
1.400	-.352	-.266	.814	-.118	-.088
1.450	-.407	-.337	.823	-.130	-.107
1.500	-.464	-.410	.832	-.142	-.124
1.550	-.523	-.487	.840	-.152	-.141
1.600	-.584	-.567	.848	-.163	-.156
1.650	-.647	-.649	.855	-.172	-.171
1.700	-.712	-.735	.862	-.182	-.186
1.750	-.780	-.823	.868	-.191	-.200
1.800	-.849	-.915	.874	-.199	-.213
1.850	-.921	-1.010	.880	-.207	-.226
1.900	-.996	-1.107	.885	-.215	-.238
1.950	-1.072	-1.208	.890	-.222	-.249
2.000	-1.151	-1.312	.894	-.229	-.260
2.050	-1.232	-1.419	.899	-.236	-.271
2.100	-1.315	-1.529	.903	-.242	-.281

TABLE 7

Faired Open Water Characteristics
P/D = 1.058 Crashahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.533	.767	0.000	.531	.768
-.050	.588	.840	-.050	.594	.835
-.100	.609	.873	-.100	.601	.866
-.150	.607	.875	-.148	.587	.859
-.200	.589	.858	-.196	.563	.825
-.250	.562	.828	-.243	.531	.777
-.300	.533	.793	-.287	.494	.724
-.350	.504	.756	-.330	.455	.673
-.400	.480	.723	-.371	.416	.625
-.450	.462	.696	-.410	.383	582
-.500	.452	.677	-.447	.357	.545
-.550	.451	.668	-.482	.340	.515
-.600	.459	.670	-.514	.332	.492
-.650	.477	.683	-.545	.332	.477
-.700	.503	.707	-.573	.337	.470
-.750	.538	.741	-.600	.347	.470
-.800	.581	.785	-.625	.359	.475
-.850	.630	.838	-.648	.372	.485
-.900	.685	.900	-.669	.386	.497
-.950	.744	.969	-.689	.398	.511
-1.000	.808	1.043	-.707	.409	.525
-1.050	.874	1.123	-.724	.419	.539
-1.100	.942	1.206	-.740	.427	.551
-1.150	1.011	1.292	-.755	.433	.561
-1.200	1.080	1.380	-.768	.438	.570
-1.250	1.150	1.470	-.781	.442	.576
-1.300	1.218	1.559	-.793	.445	.581
-1.350	1.286	1.648	-.804	.446	.583
-1.400	1.352	1.737	-.814	.447	.584
-1.450	1.417	1.824	-.823	.447	.584
-1.500	1.481	1.910	-.832	.447	.582
-1.550	1.543	1.994	-.840	.446	.580
-1.600	1.604	2.077	-.848	.445	.576
-1.650	1.664	2.158	-.855	.444	.573
-1.700	1.724	2.238	-.862	.442	.568
-1.750	1.783	2.317	-.868	.440	.564
-1.800	1.843	2.395	-.874	.438	.559
-1.850	1.903	2.473	-.880	.436	.555
-1.900	1.965	2.551	-.885	.434	.551
-1.950	2.028	2.629	-.890	.432	.546
-2.000	2.093	2.709	-.894	.430	.542
-2.050	2.161	2.791	-.899	.428	.539
-2.100	2.231	2.874	-.903	.425	.535

TABLE 8

Faired Open Water Characteristics
P/D = 0.604 Ahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.199	.277	0.000	.198	.276
.050	.186	.274	.050	.186	.275
.100	.174	.271	.100	.172	.269
.150	.161	.266	.148	.158	.260
.200	.148	.261	.196	.142	.250
.250	.134	.254	.243	.126	.239
.300	.118	.247	.287	.109	.226
.350	.101	.238	.330	.090	.212
.400	.082	.229	.371	.071	.197
.450	.061	.218	.410	.051	.182
.500	.038	.206	.447	.031	.165
.550	.013	.193	.482	.010	.149
.600	-.013	.178	.514	-.010	.131
.650	-.042	.162	.545	-.030	.114
.700	-.073	.145	.573	-.050	.097
.750	-.106	.126	.600	-.068	.080
.800	-.140	.106	.625	-.086	.064
.850	-.177	.084	.648	-.103	.048
.900	-.215	.061	.669	-.119	.033
.950	-.254	.036	.689	-.134	.018
1.000	-.296	.009	.707	-.148	.004
1.050	-.339	-.019	.724	-.161	-.009
1.100	-.384	-.049	.740	-.173	-.022
1.150	-.430	-.080	.755	-.184	-.034
1.200	-.478	-.113	.768	-.195	-.046
1.250	-.527	-.147	.781	-.205	-.057
1.300	-.579	-.183	.793	-.215	-.067
1.350	-.632	-.220	.804	-.224	-.077
1.400	-.687	-.259	.814	-.232	-.086
1.450	-.744	-.299	.823	-.240	-.095
1.500	-.802	-.340	.832	-.247	-.103
1.550	-.864	-.383	.840	-.254	-.111
1.600	-.927	-.427	.848	-.261	-.119
1.650	-.992	-.472	.855	-.268	-.126
1.700	-1.060	-.518	.862	-.274	-.133
1.750	-1.131	-.566	.868	-.279	-.139
1.800	-1.204	-.614	.874	-.285	-.145
1.850	-1.280	-.665	.880	-.290	-.151
1.900	-1.358	-.716	.885	-.295	-.157
1.950	-1.439	-.770	.890	-.299	-.162
2.000	-1.522	-.825	.894	-.304	-.167
2.050	-1.607	-.882	.899	-.308	-.172
2.100	-1.695	-.941	.903	-.312	-.177

TABLE 9

Faired Open Water Characteristics
P/D = 0.604 Crashahead

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	.205	.282	0.000	.204	.282
-.050	.213	.282	-.050	.215	.282
-.100	.215	.278	-.100	.212	.275
-.150	.213	.272	-.148	.207	.266
-.200	.210	.266	-.196	.202	.256
-.250	.208	.261	-.243	.197	.246
-.300	.209	.257	-.287	.193	.236
-.350	.213	.256	-.330	.190	.228
-.400	.220	.257	-.371	.190	.221
-.450	.232	.260	-.410	.192	.216
-.500	.248	.267	-.447	.197	.213
-.550	.267	.276	-.482	.204	.212
-.600	.290	.288	-.514	.213	.212
-.650	.317	.302	-.545	.223	.213
-.700	.346	.319	-.573	.234	.214
-.750	.378	.337	-.600	.244	.216
-.800	.412	.357	-.625	.253	.219
-.850	.448	.378	-.648	.261	.220
-.900	.486	.402	-.669	.269	.222
-.950	.525	.426	-.689	.276	.224
-1.000	.566	.451	-.707	.282	.225
-1.050	.608	.478	-.724	.287	.227
-1.100	.652	.506	-.740	.293	.228
-1.150	.696	.535	-.755	.298	.230
-1.200	.743	.566	-.768	.302	.231
-1.250	.791	.597	-.781	.307	.233
-1.300	.840	.630	-.793	.311	.234
-1.350	.892	.664	-.804	.316	.236
-1.400	.945	.700	-.814	.320	.237
-1.450	1.001	.738	-.823	.324	.239
-1.500	1.059	.777	-.832	.328	.240
-1.550	1.120	.818	-.840	.332	.242
-1.600	1.184	.861	-.848	.335	.243
-1.650	1.250	.906	-.855	.339	.245
-1.700	1.320	.954	-.862	.342	.246
-1.750	1.391	1.003	-.868	.345	.248
-1.800	1.466	1.054	-.874	.348	.249
-1.850	1.543	1.108	-.880	.350	.251
-1.900	1.623	1.163	-.885	.353	.252
-1.950	1.705	1.221	-.890	.355	.254
-2.000	1.789	1.280	-.894	.357	.255
-2.050	1.875	1.341	-.899	.358	.257
-2.100	1.962	1.404	-.903	.360	.258

TABLE 10

Faired Open Water Characteristics
P/D = 0.000 Backing

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.031	.183	0.000	-.031	.183
-.050	-.030	.180	-.050	-.030	.179
-.100	-.027	.178	-.100	-.027	.176
-.150	-.023	.177	-.148	-.022	.173
-.200	-.017	.176	-.196	-.016	.169
-.250	-.010	.175	-.243	-.009	.165
-.300	-.001	.175	-.287	-.001	.160
-.350	.009	.174	-.330	.008	.155
-.400	.020	.174	-.371	.017	.150
-.450	.033	.174	-.410	.027	.144
-.500	.047	.173	-.447	.038	.139
-.550	.062	.173	-.482	.048	.133
-.600	.078	.172	-.514	.058	.126
-.650	.096	.171	-.545	.067	.120
-.700	.114	.169	-.573	.077	.114
-.750	.134	.167	-.600	.086	.107
-.800	.155	.165	-.625	.095	.101
-.850	.178	.163	-.648	.103	.095
-.900	.201	.160	-.669	.111	.089
-.950	.226	.157	-.689	.119	.082
-1.000	.252	.154	-.707	.126	.077
-1.050	.279	.150	-.724	.133	.071
-1.100	.308	.147	-.740	.139	.066
-1.150	.338	.143	-.755	.145	.061
-1.200	.370	.139	-.768	.152	.056
-1.250	.403	.135	-.781	.157	.052
-1.300	.438	.131	-.793	.163	.048
-1.350	.475	.127	-.804	.168	.045
-1.400	.513	.123	-.814	.173	.041
-1.450	.552	.119	-.823	.178	.038
-1.500	.594	.115	-.832	.183	.036
-1.550	.637	.112	-.840	.188	.033
-1.600	.682	.109	-.848	.192	.031
-1.650	.729	.106	-.855	.196	.029
-1.700	.778	.104	-.862	.200	.027
-1.750	.828	.102	-.868	.204	.026
-1.800	.880	.101	-.874	.208	.024
-1.850	.935	.100	-.880	.212	.023
-1.900	.991	.100	-.885	.215	.022
-1.950	1.049	.100	-.890	.219	.021
-2.000	1.109	.101	-.894	.222	.020
-2.050	1.171	.102	-.899	.225	.020
-2.100	1.234	.104	-.903	.228	.019

TABLE 11

Faired Open Water Characteristics
P/D = 0.000 Crashback

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.011	.181	0.000	-.009	.180
.050	-.044	.191	.050	-.045	.193
.100	-.073	.200	.100	-.074	.200
.150	-.101	.208	.148	-.098	.203
.200	-.127	.215	.196	-.120	.205
.250	-.151	.222	.243	-.141	.207
.300	-.175	.228	.287	-.159	.208
.350	-.198	.233	.330	-.176	.208
.400	-.222	.239	.371	-.192	.207
.450	-.246	.244	.410	-.206	.205
.500	-.270	.249	.447	-.218	.201
.550	-.296	.254	.482	-.229	.197
.600	-.323	.259	.514	-.238	.192
.650	-.352	.264	.545	-.247	.186
.700	-.382	.270	.573	-.256	.181
.750	-.414	.275	.600	-.264	.175
.800	-.449	.280	.625	-.272	.169
.850	-.485	.286	.648	-.280	.164
.900	-.524	.291	.669	-.288	.159
.950	-.565	.297	.689	-.295	.154
1.000	-.608	.303	.707	-.303	.150
1.050	-.654	.309	.724	-.310	.146
1.100	-.703	.315	.740	-.318	.142
1.150	-.754	.321	.755	-.324	.138
1.200	-.807	.327	.768	-.331	.134
1.250	-.863	.333	.781	-.338	.131
1.300	-.922	.339	.793	-.344	.127
1.350	-.983	.345	.804	-.349	.124
1.400	-1.046	.351	.814	-.355	.120
1.450	-1.112	.357	.823	-.360	.117
1.500	-1.181	.362	.832	-.365	.113
1.550	-1.251	.368	.840	-.369	.110
1.600	-1.324	.373	.848	-.373	.106
1.650	-1.400	.377	.855	-.377	.103
1.700	-1.477	.382	.862	-.381	.100
1.750	-1.557	.386	.868	-.384	.096
1.800	-1.639	.389	.874	-.387	.093
1.850	-1.723	.393	.880	-.390	.090
1.900	-1.809	.395	.885	-.392	.087
1.950	-1.897	.398	.890	-.395	.083
2.000	-1.987	.399	.894	-.397	.080
2.050	-2.078	.400	.899	-.399	.077
2.100	-2.172	.401	.903	-.401	.074

TABLE 12

Faired Open Water Characteristics
P/D = -0.302 Backing

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.101	-.338	0.000	-.100	-.337
-.050	-.111	-.345	-.050	-.113	-.346
-.100	-.118	-.349	-.100	-.118	-.347
-.150	-.120	-.350	-.148	-.117	-.342
-.200	-.120	-.349	-.196	-.114	-.334
-.250	-.117	-.345	-.243	-.108	-.323
-.300	-.111	-.339	-.287	-.100	-.310
-.350	-.102	-.332	-.330	-.091	-.296
-.400	-.091	-.324	-.371	-.080	-.280
-.450	-.079	-.314	-.410	-.067	-.262
-.500	-.064	-.304	-.447	-.053	-.244
-.550	-.048	-.293	-.482	-.038	-.226
-.600	-.030	-.281	-.514	-.023	-.208
-.650	-.010	-.269	-.545	-.008	-.190
-.700	.011	-.257	-.573	.007	-.172
-.750	.033	-.245	-.600	.022	-.156
-.800	.056	-.233	-.625	.035	-.141
-.850	.080	-.220	-.648	.048	-.127
-.900	.106	-.208	-.669	.060	-.114
-.950	.133	-.196	-.689	.071	-.102
-1.000	.160	-.184	-.707	.082	-.091
-1.050	.189	-.172	-.724	.091	-.081
-1.100	.219	-.161	-.740	.100	-.072
-1.150	.249	-.149	-.755	.108	-.064
-1.200	.281	-.138	-.768	.115	-.057
-1.250	.314	-.127	-.781	.122	-.050
-1.300	.347	-.116	-.793	.128	-.044
-1.350	.382	-.105	-.804	.134	-.038
-1.400	.418	-.095	-.814	.140	-.033
-1.450	.455	-.084	-.823	.145	-.028
-1.500	.493	-.074	-.832	.150	-.024
-1.550	.532	-.063	-.840	.155	-.020
-1.600	.572	-.053	-.848	.159	-.016
-1.650	.614	-.042	-.855	.163	-.012
-1.700	.657	-.031	-.862	.167	-.009
-1.750	.701	-.021	-.868	.171	-.006
-1.800	.746	-.009	-.874	.175	-.003
-1.850	.793	.002	-.880	.178	-.000
-1.900	.841	.013	-.885	.182	.003
-1.950	.890	.025	-.890	.185	.005
-2.000	.941	.038	-.894	.188	.007
-2.050	.994	.050	-.899	.191	.010
-2.100	1.048	.063	-.903	.194	.012

TABLE 13

Faired Open Water Characteristics
P/D = -0.302 Crashback

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.091	-.339	0.000	-.093	-.341
.050	-.100	-.342	.050	-.096	-.336
.100	-.114	-.350	.100	-.112	-.346
.150	-.133	-.363	.148	-.132	-.358
.200	-.156	-.378	.196	-.153	-.367
.250	-.184	-.396	.243	-.175	-.375
.300	-.215	-.417	.287	-.198	-.382
.350	-.251	-.440	.330	-.222	-.389
.400	-.290	-.465	.371	-.247	-.397
.450	-.332	-.491	.410	-.272	-.406
.500	-.376	-.519	.447	-.299	-.414
.550	-.424	-.547	.482	-.324	-.421
.600	-.473	-.576	.514	-.349	-.426
.650	-.524	-.605	.545	-.371	-.429
.700	-.577	-.635	.573	-.391	-.430
.750	-.631	-.665	.600	-.408	-.429
.800	-.686	-.695	.625	-.422	-.426
.850	-.741	-.725	.648	-.434	-.422
.900	-.797	-.756	.669	-.443	-.417
.950	-.853	-.786	.689	-.450	-.412
1.000	-.909	-.816	.707	-.454	-.406
1.050	-.965	-.847	.724	-.457	-.399
1.100	-1.021	-.877	.740	-.459	-.393
1.150	-1.077	-.907	.755	-.459	-.386
1.200	-1.132	-.937	.768	-.459	-.380
1.250	-1.188	-.968	.781	-.458	-.374
1.300	-1.243	-.998	.793	-.456	-.368
1.350	-1.298	-1.029	.804	-.454	-.362
1.400	-1.353	-1.059	.814	-.451	-.356
1.450	-1.408	-1.090	.823	-.449	-.351
1.500	-1.464	-1.121	.832	-.446	-.345
1.550	-1.520	-1.153	.840	-.444	-.340
1.600	-1.577	-1.184	.848	-.441	-.335
1.650	-1.635	-1.216	.855	-.439	-.329
1.700	-1.693	-1.249	.862	-.437	-.324
1.750	-1.754	-1.281	.868	-.434	-.319
1.800	-1.815	-1.314	.874	-.432	-.314
1.850	-1.879	-1.348	.880	-.430	-.309
1.900	-1.945	-1.382	.885	-.429	-.304
1.950	-2.013	-1.417	.890	-.427	-.299
2.000	-2.084	-1.452	.894	-.425	-.295
2.050	-2.158	-1.487	.899	-.424	-.290
2.100	-2.234	-1.523	.903	-.423	-.285

TABLE 14

Faired Open Water Characteristics
P/D = -0.604 Backing

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.217	-.625	0.000	-.217	-.625
-.050	-.238	-.656	-.050	-.236	-.653
-.100	-.255	-.674	-.100	-.253	-.669
-.150	-.266	-.683	-.148	-.260	-.668
-.200	-.271	-.683	-.196	-.259	-.656
-.250	-.270	-.678	-.243	-.253	-.637
-.300	-.264	-.668	-.287	-.243	-.613
-.350	-.254	-.655	-.330	-.228	-.584
-.400	-.241	-.639	-.371	-.208	-.552
-.450	-.224	-.622	-.410	-.187	-.517
-.500	-.205	-.603	-.447	-.164	-.482
-.550	-.185	-.583	-.482	-.141	-.447
-.600	-.163	-.563	-.514	-.119	-.413
-.650	-.141	-.541	-.545	-.099	-.380
-.700	-.118	-.519	-.573	-.079	-.348
-.750	-.095	-.496	-.600	-.061	-.318
-.800	-.071	-.472	-.625	-.044	-.289
-.850	-.046	-.448	-.648	-.028	-.261
-.900	-.021	-.423	-.669	-.012	-.234
-.950	.006	-.397	-.689	.003	-.209
-1.000	.033	-.370	-.707	.017	-.185
-1.050	.061	-.344	-.724	.030	-.163
-1.100	.090	-.316	-.740	.042	-.142
-1.150	.120	-.289	-.755	.053	-.123
-1.200	.152	-.262	-.768	.063	-.106
-1.250	.184	-.235	-.781	.073	-.090
-1.300	.217	-.208	-.793	.082	-.076
-1.350	.252	-.182	-.804	.090	-.064
-1.400	.287	-.156	-.814	.097	-.053
-1.450	.322	-.131	-.823	.103	-.043
-1.500	.358	-.107	-.832	.109	-.034
-1.550	.395	-.084	-.840	.115	-.026
-1.600	.431	-.063	-.848	.119	-.019
-1.650	.468	-.042	-.855	.124	-.013
-1.700	.505	-.021	-.862	.128	-.007
-1.750	.543	-.002	-.868	.132	-.002
-1.800	.581	.017	-.874	.136	.003
-1.850	.619	.035	-.880	.139	.007
-1.900	.657	.053	-.885	.142	.011
-1.950	.697	.072	-.890	.145	.015
-2.000	.738	.090	-.894	.148	.019
-2.050	.779	.110	-.899	.151	.022
-2.100	.823	.130	-.903	.154	.026

TABLE 15

Faired Open Water Characteristics
P/D = -0.604 Crashback

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.213	-.628	0.000	-.213	-.627
.050	-.133	-.540	.050	-.134	-.541
.100	-.111	-.518	.100	-.108	-.510
.150	-.126	-.535	.148	-.122	-.523
.200	-.162	-.575	.196	-.158	-.555
.250	-.210	-.625	.243	-.199	-.590
.300	-.263	-.680	.287	-.241	-.623
.350	-.318	-.734	.330	-.281	-.652
.400	-.372	-.787	.371	-.319	-.677
.450	-.425	-.838	.410	-.353	-.697
.500	-.477	-.887	.447	-.384	-.712
.550	-.530	-.937	.482	-.410	-.721
.600	-.584	-.987	.514	-.431	-.727
.650	-.640	-1.038	.545	-.450	-.730
.700	-.699	-1.093	.573	-.468	-.731
.750	-.760	-1.150	.600	-.484	-.734
.800	-.824	-1.211	.625	-.500	-.736
.850	-.890	-1.275	.648	-.515	-.739
.900	-.959	-1.341	.669	-.529	-.741
.950	-1.030	-1.409	.689	-.542	-.742
1.000	-1.103	-1.478	.707	-.553	-.742
1.050	-1.175	-1.548	.724	-.561	-.739
1.100	-1.248	-1.618	.740	-.567	-.735
1.150	-1.320	-1.687	.755	-.571	-.728
1.200	-1.391	-1.754	.768	-.572	-.719
1.250	-1.461	-1.819	.781	-.571	-.709
1.300	-1.529	-1.882	.793	-.568	-.698
1.350	-1.595	-1.943	.804	-.564	-.686
1.400	-1.660	-2.001	.814	-.559	-.673
1.450	-1.724	-2.058	.823	-.553	-.660
1.500	-1.786	-2.113	.832	-.547	-.648
1.550	-1.848	-2.168	.840	-.541	-.635
1.600	-1.910	-2.222	.848	-.535	-.623
1.650	-1.973	-2.277	.855	-.529	-.612
1.700	-2.037	-2.333	.862	-.523	-.601
1.750	-2.104	-2.391	.868	-.518	-.591
1.800	-2.172	-2.452	.874	-.513	-.581
1.850	-2.244	-2.515	.880	-.509	-.572
1.900	-2.319	-2.581	.885	-.505	-.563
1.950	-2.39.	-2.650	.890	-.501	-.555
2.000	-2.480	-2.723	.894	-.498	-.547
2.050	-2.566	-2.798	.899	-.495	-.540
2.100	-2.655	-2.877	.903	-.492	-.533

TABLE 16

Faired Open Water Characteristics
P/D = -1.058 Backing

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.514	-1.429	0.000	-.514	-1.429
-.050	-.523	-1.463	-.050	-.522	-1.460
-.100	-.528	-1.484	-.100	-.523	-1.468
-.150	-.529	-1.495	-.148	-.518	-1.461
-.200	-.527	-1.496	-.196	-.507	-1.440
-.250	-.520	-1.490	-.243	-.490	-1.403
-.300	-.511	-1.478	-.287	-.469	-1.356
-.350	-.499	-1.460	-.330	-.444	-1.299
-.400	-.484	-1.437	-.371	-.417	-1.238
-.450	-.467	-1.410	-.410	-.389	-1.173
-.500	-.449	-1.380	-.447	-.359	-1.105
-.550	-.429	-1.348	-.482	-.329	-1.036
-.600	-.407	-1.312	-.514	-.299	-.966
-.650	-.384	-1.275	-.545	-.270	-.897
-.700	-.360	-1.236	-.573	-.242	-.829
-.750	-.336	-1.195	-.600	-.215	-.764
-.800	-.310	-1.152	-.625	-.189	-.701
-.850	-.284	-1.108	-.648	-.165	-.642
-.900	-.257	-1.062	-.669	-.142	-.587
-.950	-.229	-1.015	-.689	-.120	-.534
-1.000	-.200	-.967	-.707	-.100	-.484
-1.050	-.170	-.916	-.724	-.081	-.437
-1.100	-.140	-.865	-.740	-.064	-.393
-1.150	-.108	-.812	-.755	-.047	-.351
-1.200	-.076	-.757	-.768	-.031	-.311
-1.250	-.042	-.701	-.781	-.016	-.274
-1.300	-.008	-.645	-.793	-.003	-.239
-1.350	.027	-.587	-.804	.010	-.207
-1.400	.064	-.529	-.814	.022	-.177
-1.450	.101	-.470	-.823	.033	-.150
-1.500	.139	-.410	-.832	.043	-.125
-1.550	.178	-.351	-.840	.053	-.102
-1.600	.218	-.292	-.848	.061	-.081
-1.650	.258	-.233	-.855	.069	-.062
-1.700	.299	-.175	-.862	.077	-.045
-1.750	.340	-.118	-.868	.083	-.029
-1.800	.382	-.061	-.874	.090	-.015
-1.850	.424	-.007	-.880	.095	-.003
-1.900	.466	.047	-.885	.100	.009
-1.950	.509	.099	-.890	.105	.019
-2.000	.552	.150	-.894	.110	.028
-2.050	.595	.199	-.899	.114	.037
-2.100	.638	.247	-.903	.117	.044

TABLE 17

Faired Open Water Characteristics
P/D = -1.058 Crashback

J	K_T	$10K_Q$	μ	C_T	$10C_Q$
0.000	-.516	-1.431	0.000	-.514	-1.429
.050	-.455	-1.362	.050	-.463	-1.370
.100	-.420	-1.314	.100	-.403	-1.286
.150	-.406	-1.288	.148	-.394	-1.257
.200	-.409	-1.282	.196	-.403	-1.245
.250	-.427	-1.296	.243	-.410	-1.229
.300	-.456	-1.327	.287	-.416	-1.214
.350	-.494	-1.375	.330	-.431	-1.213
.400	-.538	-1.436	.371	-.456	-1.229
.450	-.589	-1.510	.410	-.488	-1.255
.500	-.644	-1.594	.447	-.520	-1.283
.550	-.702	-1.687	.482	-.547	-1.306
.600	-.763	-1.786	.514	-.568	-1.322
.650	-.826	-1.890	.545	-.584	-1.331
.700	-.892	-1.998	.573	-.596	-1.336
.750	-.958	-2.107	.600	-.607	-1.340
.800	-1.026	-2.218	.625	-.618	-1.342
.850	-1.095	-2.328	.648	-.629	-1.342
.900	-1.165	-2.438	.669	-.639	-1.342
.950	-1.236	-2.546	.689	-.648	-1.338
1.000	-1.308	-2.652	.707	-.656	-1.331
1.050	-1.380	-2.756	.724	-.661	-1.319
1.100	-1.452	-2.857	.740	-.664	-1.303
1.150	-1.525	-2.955	.755	-.664	-1.283
1.200	-1.597	-3.050	.768	-.662	-1.259
1.250	-1.670	-3.144	.781	-.658	-1.233
1.300	-1.743	-3.234	.793	-.652	-1.205
1.350	-1.816	-3.324	.804	-.645	-1.177
1.400	-1.889	-3.411	.814	-.637	-1.148
1.450	-1.962	-3.498	.823	-.629	-1.120
1.500	-2.035	-3.585	.832	-.620	-1.094
1.550	-2.107	-3.671	.840	-.612	-1.069
1.600	-2.180	-3.759	.848	-.604	-1.045
1.650	-2.253	-3.849	.855	-.597	-1.024
1.700	-2.327	-3.940	.862	-.590	-1.004
1.750	-2.401	-4.034	.868	-.584	-.986
1.800	-2.476	-4.131	.874	-.578	-.970
1.850	-2.553	-4.233	.880	-.573	-.955
1.900	-2.630	-4.338	.885	-.568	-.942
1.950	-2.710	-4.448	.890	-.564	-.929
2.000	-2.791	-4.563	.894	-.560	-.918
2.050	-2.875	-4.683	.899	-.556	-.907
2.100	-2.962	-4.808	.903	-.553	-.898

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